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NOTES ON THE BEHAVIOUR OF THE ANEMOGRAPH AT LIZARD

COMPILED FROM REPORTS BY M. J. THOMAS, B.Sc.

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NOTES ON THE BEHAVIOUR OF THE ANEMOGRAPH AT LIZARD

COMPILED FROM REPORTS BY M. J. THOMAS, B.Sc.

In May 1932 a meteorological reporting station was opened at Lizard and towards the latter end of the year an anemometer was erected. The behaviour of this anemometer was very erratic with winds from certain directions and an examination revealed that this behaviour was due to the formation of lee eddies behind certain buildings.* The purpose of this note is to give the observations made by Mr. M. J. Thomas during this examination. The note is to a large extent quotation from the report of that officer.

Site.—The hamlet of Lizard lies on the edge of a plateau 240 to 250 ft. above sea level, which extends northwards. The road to Helston lies on this plateau and the surrounding country provides a flat open exposure. From Lizard towards Lizard Head the ground falls away at first gradually and then, near the coast, abruptly to sea level. The coastguard station, in the neighbourhood of which

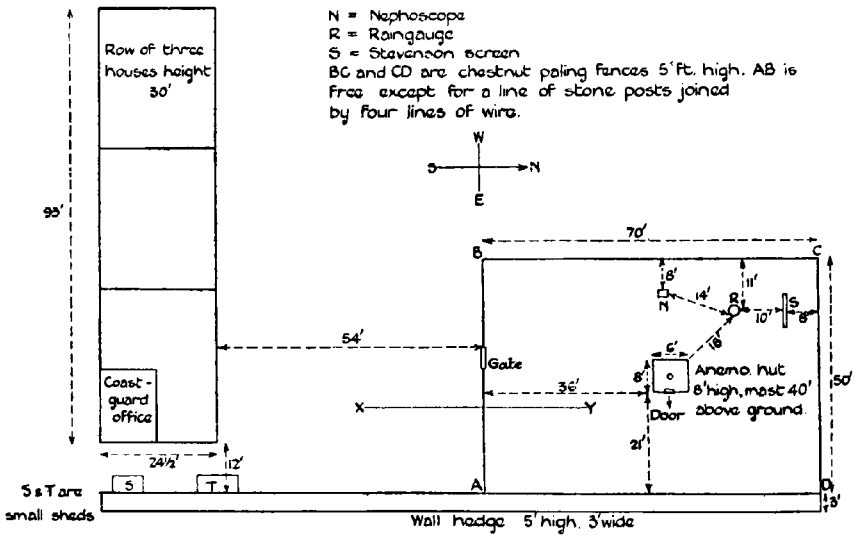

FIG. 1.—PLAN OF METEOROLOGICAL ENCLOSURE AND COASTGUARD STATION OF LIZARD.

the anemometer was erected, is situated south-south-west of Lizard, above the 200 ft. contour and marks the point at which the ground begins to slope away to the sea distant about 800 yards. To the north of the coastguard compound is a flat level field but the compound itself slopes towards the south-south-west albeit gradually. The anemometer was placed in the centre of an intake from this field as is shown on the plan in Fig. 1. The height of the anemometer

*In the Fourth Report on Wind Structure (*London, Rep. Memor. adv. Comm. Aero.* 92) J. S. Dines has given an example of a similar lee eddy formed behind a building at Pyrton Hill.

[*To face page 2*

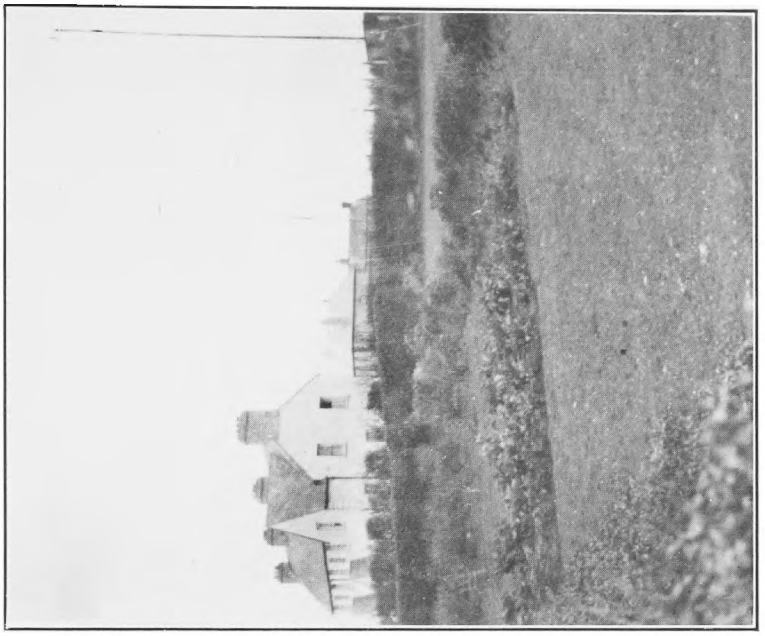

FIG. 3.

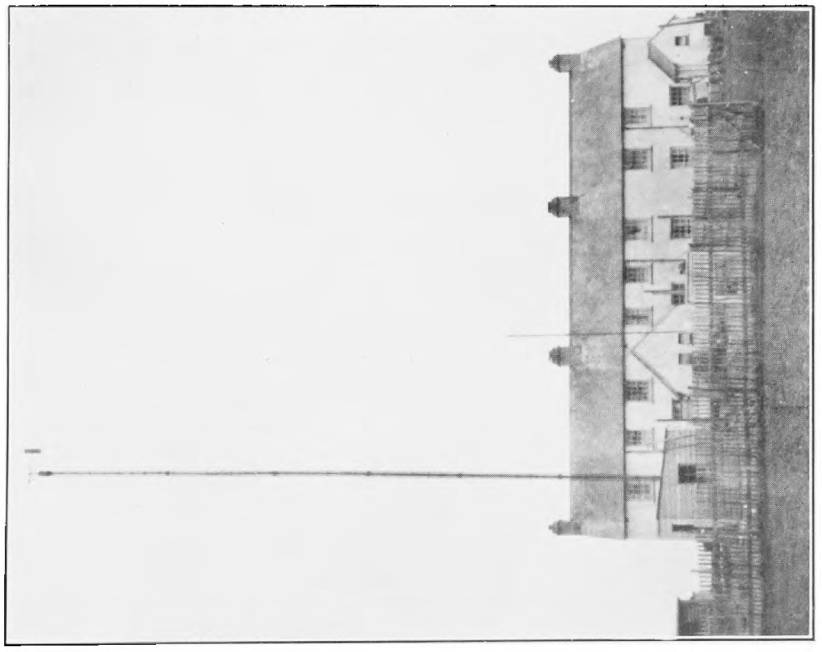

FIG. 2.

FIG. 4.

FIG. 5.

head was 40 ft. above ground level. In the light of the observations given in this report it was subsequently increased to 75 ft. In addition to the coastguard houses shown on this plan there are isolated houses of average height to west-north-west, to east by north and to north of the enclosure at distances of about 50 to 70 yards. Photographs showing the houses in the neighbourhood are exhibited in Figs. 2 to 5.

Observations.—The anemograms made at this site showed a normal amount of fluctuations from most directions, but when the general wind current was between 200° and 250° the vane fluctuated wildly and in some cases boxed the compass rapidly for hours on end.* An example is given in Fig. 6 (folder) (March 16-17, 1933). This shows clearly the extreme fluctuations between 11h. and 12h., 15h. 30m. and 18h., 20h. and 22h. 45m. and during two periods after midnight. There is also a period with excessive fluctuations between 23h. and 0h. 20m. when the wind was passing over the house to west-north-west before it reached the anemometer.

Investigation and Conclusions.—To ascertain the cause of this erratic behaviour, Mr. M. J. Thomas was instructed to visit the site and investigate the phenomenon. Two visits were paid, the first on March 3, 1933, the second on March 18, 1933. Extracts from the reports of these visits are given below :—

On the first visit, in order to examine the wind disturbances between the houses and the anemometer, three methods were employed. (*a*) Balloons were filled with hydrogen to give practically zero lift and let off on the windward side of the houses and their approximate tracks noted. A few balloons were released between the houses and the anemometer and their behaviour noted. (*b*) Zero lift balloons were tethered by a very light twine and their behaviour noted when allowed to float about the region between the houses and the anemometer. (*c*) Bamboo poles with long streamers attached to the ends were so erected as to clear the vane by different heights namely, 20 ft., 15ft., 10ft., and also at the level of the vane.

Arriving at the station on Friday, the 3rd, there being strong south-westerly winds at the time, it was decided to take advantage of the wind and a number of experiments were carried out under methods (*a*) and (*b*) until dark. The experiments were carried on, on Sunday, the 5th, and completed at 13h. 30m.

The result of experiments under (*a*) and (*b*) showed that the general nature of the wind current in the lee of the houses is as given in Fig.7. The free balloons with zero lift, drifting over the vane within a height of 0 to 10 ft. above it were in many cases brought down near the ground at about 75 ft. north of the mast, and brought back by a return current. The line of separation AB between the main and return air currents varied considerably, but the maximum height of this line above ground appeared to be about 55 to 60 ft. With a main wind speed of 25 to 30 m.p.h. from a south-westerly direction a return wind varying in speed occasionally between 5 and 10 m.p.h. was found at head level between the houses and the mast. By watching the

* From an examination of the anemograms it seems that if the wind is less than about 10 miles per hour there is no abnormal fluctuation but when the wind rises above that value (from the critical direction) then there are fluctuations.

behaviour of the balloon tethered by a very light string and allowed to drift near the mast head and noting the track of free balloons of zero lift, it was found that there was an almost stationary eddy with a maximum diameter of about 30 ft. centred at the level of the vane head and broken almost continually by violent eddies of small diameter varying according to the strength of the wind current. The diameter was mainly of the order 3 to 5 ft. These small eddies were particularly noticeable within the regions of

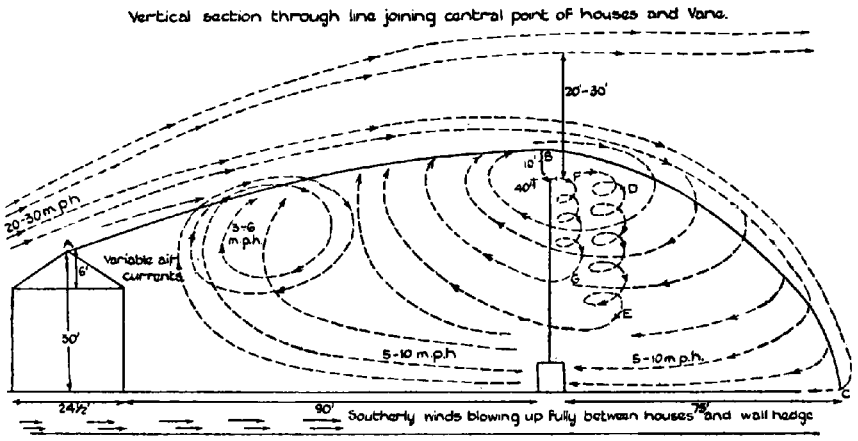

FIG. 7.—GENERAL PLAN OF AIR MOVEMENTS.

the immediate south side of the anemometer. The tethered balloons were caught a number of times in these eddies and their approximate track is shown by DE and FG in Fig. 7, the balloon descending in a sort of spiral motion. These small eddies were also made evident by the behaviour of a few balloons let off free to windward of the houses. Further eddies of about the same maximum diameter, 30 ft., were found between the mast and the houses on the east and west side of the line joining the mast to the central

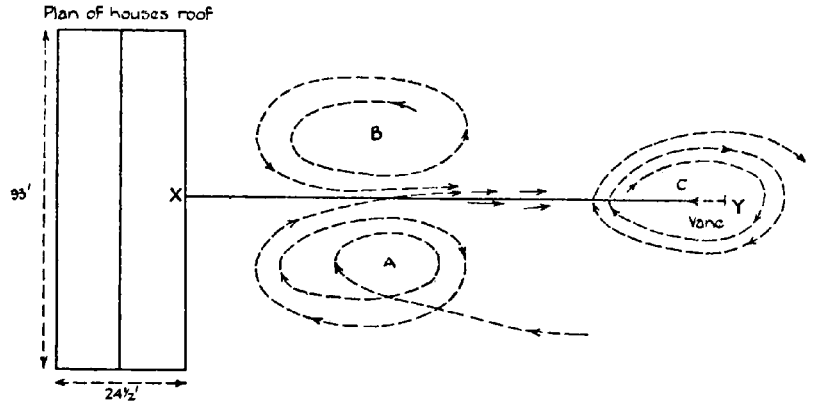

FIG. 8.

point of the houses. In Fig. 8 XY represents the line between the vane of the anemometer and the centre of the houses and A,B,C are the three distinct eddies. A and C had a clockwise movement of the air current and B an anti-clockwise movement.

A number of balloons filled with sufficient hydrogen to clear the vane of the anemometer by from 20 to 30 ft. were carried on in the main air stream without appreciable disturbance. When the main wind current was SSW. 25 to 35 m.p.h. it was noticed that between points X and Y in Fig. 1, a 15 m.p.h. E. wind prevailed at head level, probably due to the effect of the SSW. wind blowing up the gully between the houses and the wall hedge and completely deflecting to right angles the return air current at the surface. With a SW. wind the deflection was not so pronounced and the resultant wind about 10 m.p.h. Fig. 9 shows some of the approximate tracks to scale of the balloons let off at zero lift to windward of the houses.

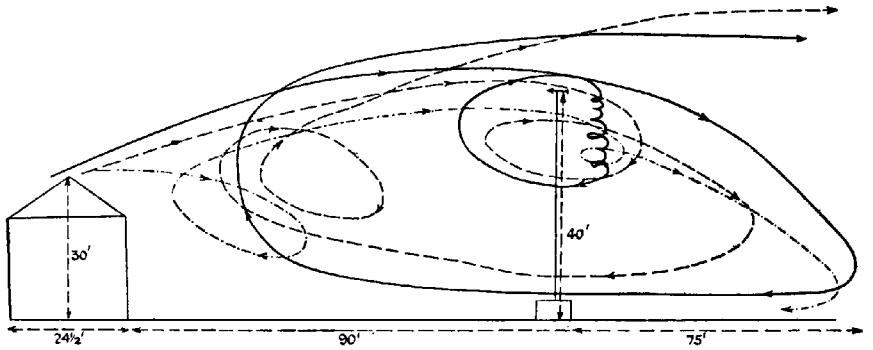

FIG. 9.

In regard to method (*c*) the following procedure was adopted. Bamboo poles were firmly lashed together to give a rod 26 ft. long and about 6 ft. of the rod secured firmly to the mast head after removing the vane to allow the streamers to clear the head by 20 ft. The wind bent the rod over so that actually the streamers were almost continually at the level of about 15 ft. above mast head. Similarly a 20 ft. rod was constructed and firmly lashed to the mast so that the streamers should be at 15 ft. above the mast but actually were only at about 10 ft. for most of the time. Under the circumstances it was found impracticable to erect another pole with streamers at the 10 ft. level and a pole was erected somewhat inclined to the mast so as to bring the streamers to the level of the vane without entangling them. These streamers at the various levels will be denoted by X for the 20 ft., Y for the 15 ft., and Z for the vane level. The movements of all three streamers X, Y, Z were observed simultaneously for about 1½ hours with a main wind between SW. and SSW. blowing at force 7.

The streamers of X behaved more steadily than Y and Z but generally were inclined at about 15° or 20° from the horizontal to the ground. Very occasionally the streamers would whip round the end of the pole in a great circle and at times would be blown vertically upwards and remain in the vertical position for a second . They were often whipped round to east from the normal south-west to north-east line and less often would whip round to the north-west position. There was evidence of definite but only occasional disturbances, sometimes violent in the general wind stream at their level.

Y were much more disturbed, and generally slightly more inclined to the ground than X and described more circles in both vertical and horizontal planes.

Z did everything imaginable in the way of movements and were almost continually describing circles or whipping vertically upwards or downwards. They showed very definite evidence of violent disturbances in the wind stream at the level of the vane. Within half-an-hour the streamers were broken by entangling with their own pole, the anemometer mast and the other pole, so violent were their movements.

When removing the vane on Sunday the 5th, between 9 and 10 a.m., and later at about 1.30 p.m., when attempting to replace the vane, I found that the wind was continually changing direction. When holding the vane with both hands with the head to the main wind after removing it from the mast, it was nearly whipped out of my hand by a fierce and almost constant succession of small eddies.

Balloons released to windward of the houses with just sufficient lift to clear the mast head with a margin of at least 20 ft. seemed to me to indicate that the main wind speed flowed practically undisturbed at and above a height of 20 to 30 ft. above the present level of the vane.

The second visit was made to examine the effects of north-westerly winds in creating eddies but whilst waiting for NW. winds a south-westerly strong wind set in on Sunday, March 19 and I decided to carry out a number of experiments with balloons filled with hydrogen to give zero lift to confirm my previous experiments detailed in my first report, dated March 11, 1933. As before a number of balloons were released to windward and some to leeward of the coastguard houses and the tracks of these balloons carefully noted. Some of the tracks are shown in Fig. 10, and are numbered and the details of them described below. In all cases the wind was from SW. and the mean speed 30 to 35 m.p.h.

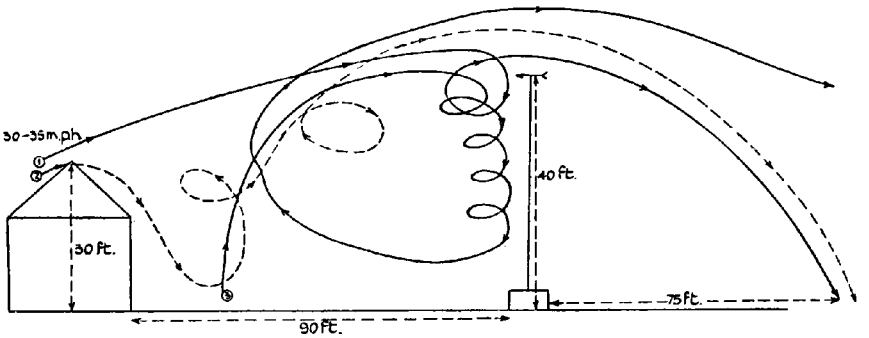

FIG. 10.—TRACKS OF SOME BALLOONS RELEASED DURING SW. WINDS, 30–35 M.P.H. AT THE LIZARD.

No. 1. The balloon cleared the houses by about 10 ft. and descended to the level of the vane where it was caught by a small eddy before being brought to the ground 25 yards north of the mast.

No. 2. The balloon hit the houses, turned to the right before passing over the top and was brought down almost to the ground 10 yards north-east of the houses. It then returned along the ground to a position between the houses and the mast and was caught by two eddies as shown and finally came to ground 25 yards north of the mast.

No. 3. This one was released about 5 yards north of the middle point of the houses and rose vertically until caught by the descending current which fetched it to ground level near the mast in a violent spiral motion. Then it returned at head level to near the houses, was taken vertically upwards and finally passed 15 ft. over the vane somewhat to east of it.

The examination of north-westerly winds could not be made until the morning of the 20th, when the wind veered to WNW. and experiments were carried out on similar lines to those previously made in south-westerly winds.

The house responsible for the wind disturbance stands 40 ft. high to west-north-west of the anemometers at a distance of 65 yards and its line runs approximately north and south. The main wind stream was from WNW. to NW. and the mean speed about 25 m.p.h. Free balloons with zero lift were

released to windward of the house and also on the lee side and their behaviour noted. By noting the tracks it was found that the general nature of the wind currents between the anemometer and the house were as shown in Fig. 11. Some of the balloons freed to windward of the house passed over the top and were brought down to within 5 ft. of the ground and brought back to the house by a slow moving current, then lifted by a vertical current into the main stream and were carried along with a downward drift near to the ground about 20 yards from the anemometer where an upward current carried them past the mast generally below the level of the vane. The tracks of a number of balloons let off on the lee side of the house corroborated the evidence of the existence of the large eddy as shown in Fig. 11 and were also affected by the upward current before reaching the anemometer.

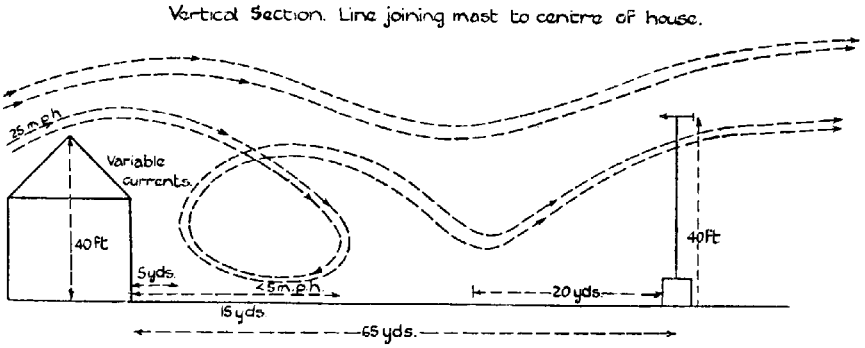

FIG. 11.—GENERAL NATURE OF WIND CURRENTS BETWEEN THE HOUSE AND THE ANEMOMETER.

After completing the experiments with balloons the vane was removed and bamboo poles erected with paper streamers attached so as to clear the vane head by 20 and 15 ft. and at the level of the vane. The streamers were observed simultaneously for 1½ hours with the main wind blowing from between WNW. and NW. with a speed of about 25 m.p.h. The streamers at the 20 ft. level blew steadily and practically horizontally throughout the period and seemed to be affected by the main wind stream only. Those at the 15 ft. level were fairly steady but for most of the time remained inclined above the horizontal at an angle varying between 5° and 15° and occasionally were whipped upwards to about 45° . The streamers at vane level were also fairly steady in motion but their general line of flow was inclined above the horizontal by from 15° to 30° and occasionally were whipped upwards at an angle of about 50°. The streamers at all levels very seldom were deviated from the horizontal towards the ground but for short periods they were kept horizontal in the case of the 15 ft. and vane levels.

Following upon Mr. Thomas' experiments the height of the anemometer head was raised in April, 1934 to 75 ft. above the ground and this alteration brought about a cessation of the excessive fluctuation with south-westerly and west-north-west winds. An example of a record with south-westerly gales made after the raising of the head is given in Fig. 12 (Sept. 16, 1935, 17h-24h) which should be compared with Fig. 6.

The behaviour of the Lizard anemometer before and after the raising of the head illustrates the importance of the head of an anemometer being high enough to be clear of eddies caused by neighbouring objects.

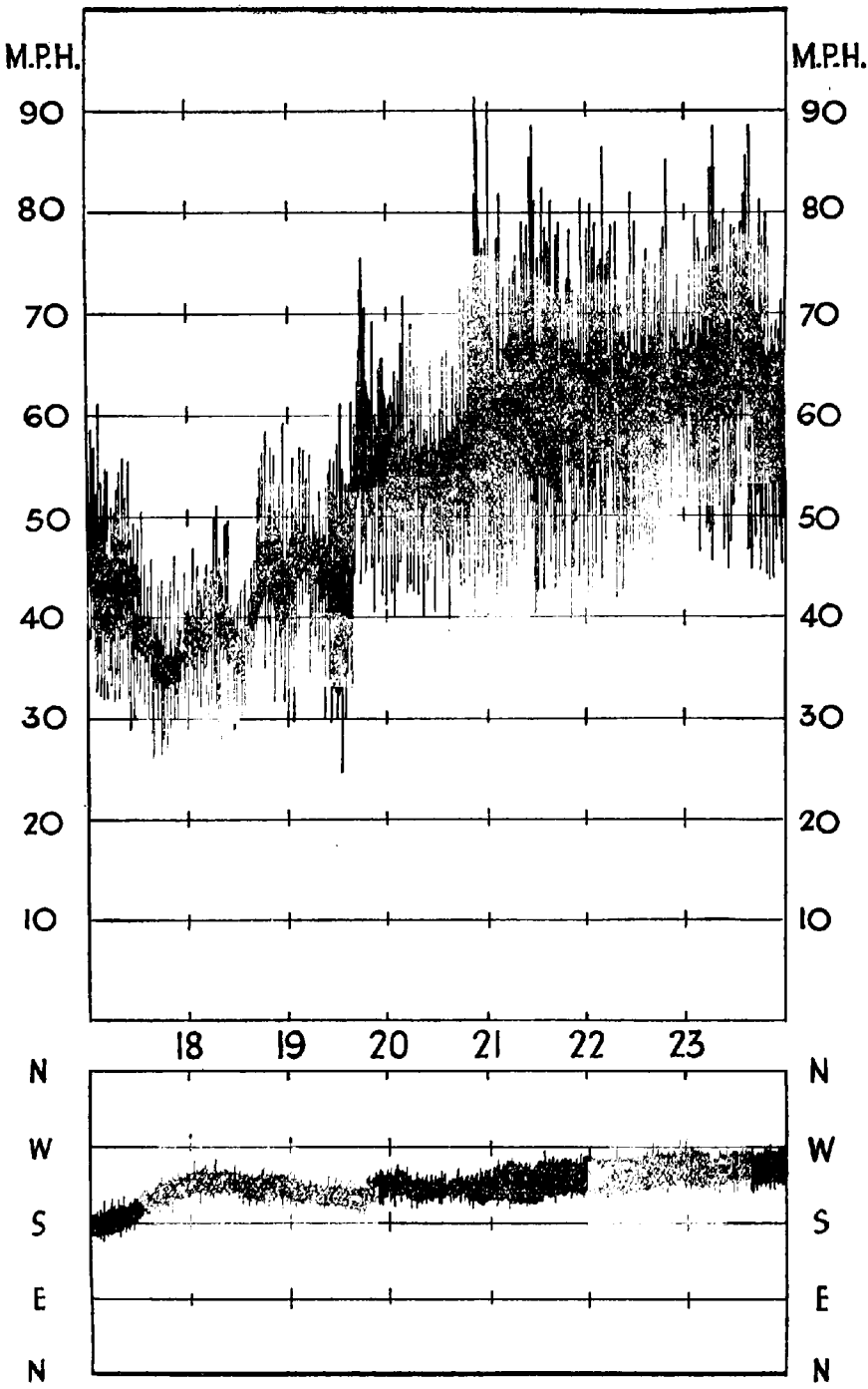

FIG. 12.—ANEMOGRAM, LIZARD, SEPTEMBER 16, 1935, 17H. TO 24H.

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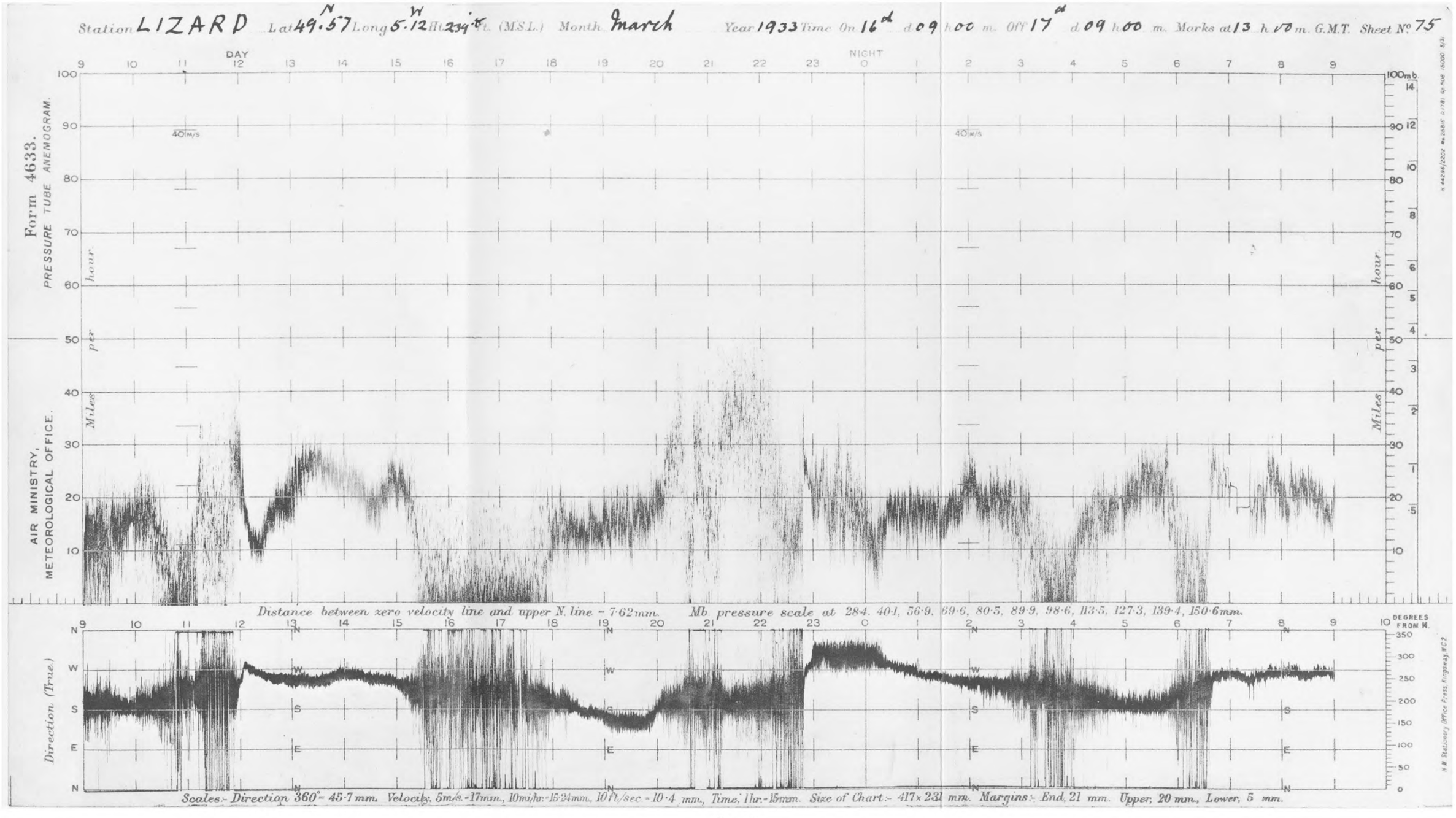
Station LIZARD Lat 49.57 N Long 5.12 W Ht 239 ft. (M.S.L.) Month March Year 1933 Time On 16th d 09 h 00 m. Off 17th d 09 h 00 m. Marks at 13 h 10 m. G.M.T. Sheet No. 75
DAY
NIGHT
Form 4633.
PRESSURE TUBE ANEMOGRAM.
AIR MINISTRY, METEOROLOGICAL OFFICE.
Miles per hour
40 M/S
100 mb
Distance between zero velocity line and upper N. line = 7·62 mm. Mb. pressure scale at 28·4, 40·1, 56·9, 69·6, 80·5, 89·9, 98·6, 113·5, 127·3, 139·4, 150·6 mm.
Direction (True)
DEGREES FROM N.
Scales:- Direction 360° = 45·7 mm. Velocity, 5 m/s. = 17 mm., 10 mi/hr. = 15·24 mm., 10 ft/sec. = 10·4 mm., Time, 1 hr. = 15 mm. Size of Chart:- 417 x 231 mm. Margins:- End, 21 mm. Upper, 20 mm., Lower, 5 mm.

FIG. 6